SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, DECEMBER 9, 1904.

CONTENTS:

MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

*THE RECENT DEVELOPMENT OF BIOLOGY.**

I.

THE task allotted to me on this occasion is a review of the development of biology during the last century. The limited time at our disposal will necessitate many omissions and will force me to confine myself to the discussion of a few of the departures in biology which have led or promise to lead to fertile discoveries.

The problem of a scientific investigator can always be reduced to two tasks; the first, to determine the independent variables of the phenomena which he has under investigation, and secondly, to find the formula which allows him to calculate the value of the function for every value of the variable. In physics and chemistry the independent variables are in many cases so evident that the investigation may begin directly with the quantitative determination of the relation between the change of the essential variable and the function. In biology, however, the variables, as a rule, can not be recognized so easily and a great part of the mental energy of the investigators must be spent in the search for these variables. To give an example, we know that in many eggs the development only begins after the entrance of a spermatozoon into the egg. The spermatozoon must produce some kind of a change in the egg, which is responsible for the development. But we do not know which variable in the egg is changed by the spermatozoon, whether the latter pro-

* Address delivered at the Congress of Arts and Science in St. Louis.

duces a chemical or an osmotic change, or whether it brings about a change of phase or some other effect. It goes without saying that a theory of sexual fertilization is impossible until the independent variable in the process of sexual fertilization is known.

But the investigations of the biologist differ from those of the chemist and physicist in that the biologist deals with the analysis of the mechanism of a special class of machines. Living organisms are chemical machines, made of essentially colloidal material which possess the peculiarity of developing, preserving and reproducing themselves automatically. The machines which have thus far been produced artificially lack the peculiarity of developing, growing, preserving and reproducing themselves, though no one can say with certainty that such machines might not one day be constructed artificially.

The specific and main work of the biologist will, therefore, be directed toward the analysis of the automatic mechanisms of development of self-preservation and reproduction.

II.

THE DYNAMICS OF THE CHEMICAL PROCESSES IN LIVING ORGANISMS.

The progress made by chemistry, especially physical chemistry, has definitely put an end to the idea that the chemistry of living matter is different from the chemistry of inanimate matter. The presence of catalyzers in all living tissues makes it intelligible that in spite of the comparatively low temperature at which life phenomena occur the reaction velocities for the essential processes in living organisms are comparatively high. It has been shown, moreover, that the action of the catalyzers found in living organisms can be imitated by certain metals or other inorganic catalyzers. We may, therefore, say that it is now proved beyond all doubt that the variables in the chemical processes in living organisms are identical with those with which the chemist has to deal in the laboratory. As a consequence of this result chemical biology has during the last years entered into the series of those sciences which are capable of predicting their results quantitatively. The application of the theory of chemical equilibrium to life phenomena has led biological chemists to look for reversible chemical processes in living organisms and the result is the discovery of the reversible enzyme actions, which we owe to A. C. Hill. I think it marks the beginning of a new epoch of the physiology of metabolism that we now know that the same enzymes not only accelerate the hydrolysis, but also in some cases, if not generally, the synthesis of the products of cleavage. It is not impossible that the results thus obtained in the field of biology will ultimately in return benefit chemistry, inasmuch as they may enable chemistry to accomplish syntheses with the help of enzymes found in living organisms which could otherwise not be so easily obtained.

A very beautiful example of the conquest of biological chemistry through chemical dynamics is offered by the work of Arrhenius and Madsen. These authors have successfully applied the laws of chemical equilibrium to toxins and anti-toxins so that it is possible to calculate the degree of saturation between toxins and antitoxins for any concentration with the same ease and certainty as for any other chemical reaction.

We know as yet but little concerning the method by which enzymes produce their accelerating effects. It seems that the facts recently gathered speak in favor of the idea of intermediary reactions. According to this idea the catalyzers participate in the reaction, but form combinations that are again rapidly decom-

posed. This makes it intelligible that at the end of the reaction the enzymes and catalyzers are generally in the same condition as at the beginning of the reaction, and that a comparatively small quantity of the catalyzer is sufficient for the transformation of large quantities of the reacting substances.

This chapter should not be concluded without mentioning the discovery of zymase by Buchner. It had long been argued that only certain of the fermentative actions of yeast depended on the presence of enzymes which could be separated from the living cells, but that the alcoholic fermentation of sugar by yeast was inseparably linked together with the life of the cell. Buchner showed that the enzyme which accelerates the alcoholic fermentation of sugar can also be separated from the living cell, with this purely technical difference only, that it requires a much higher pressure to extract zymase than any other enzymes from the yeast cell.

III.

PHYSICAL STRUCTURE OF LIVING MATTER.

We have stated that living organisms are chemical machines whose framework is formed by colloidal material consisting of proteins, fatty compounds, and carbohydrates. These colloids possess physical qualities which are believed to play a great rôle in life phenomena. Among these qualities are the slow rate of diffusion, the existence of a double layer of electricity at the surface of the dissolved or suspended colloidal particles, and the production of definite structures when they are precipitated. We may consider it as probable that the cytological and histological structures of living matter will be reduced to the physical qualities of the colloids. But, inasmuch as the physics of the colloids is still in its beginning, we must not be surprised that the biological application of its results is still in the stage of mere suggestions. The most important result which has thus far been accomplished through the application of the physics of colloids to biology is Traube's invention of the semipermeable membranes. To Traube we owe the discovery that every living cell behaves as if it were surrounded with a surface film which does not possess equal permeability for water and the substances dissolved in it. Salts which are dissolved in water, as a rule, migrate much more slowly into the living cells than water. This discovery of the semi-permeability of the surface films of living protoplasm made, it possible to recognize the variable which determines the exchange of liquids between protoplasm and the liquid medium by which it is surrounded, namely, the osmotic pressure. Inasmuch as the osmotic pressure is measurable, this field of biology has entered upon a stage where every hypothesis can be tested exactly and biology is no longer compelled to carry a ballast of shallow phrases. We are now able to analyze quantitatively such functions as lymph formation and the secretion of glands.

Recent investigations have thrown some light on the nature of the conditions which seem to determine the semi-permeability of living matter. Quincke had already mentioned that a film of oil acts like a semipermeable membrane. From certain considerations of surface tension and surface energy it follows that every particle of protoplasm which is surrounded by a watery liquid must form an extremely thin film of oil at its surface. Overton has recently shown that of all dissolved substances those which possess a high solubility in fat, *e. g.*, alcohol, ether, chloroform, diffuse most easily into living cells. Overton concludes that lipoid substances such as lecithin and cholesterin which are found in every cell determine the phenom-

enon of the semi-permeability of living matter.

IV.

DEVELOPMENT AND HEREDITY.

We now come to the discussion of those phenomena which constitute the specific difference between living machines and the machines which we have thus far been able to make artificially. Living organisms show the phenomena of development. During the last century it was ascertained that the development of an animal egg, in general, does not occur until a spermatozoon has entered it, but, as already stated, we do not know which variable in the egg is changed by the spermatozoon. An attempt has been made to fill the gap by causing unfertilized eggs to develop with the aid of physicochemical means. The decisive variable by which such an artificial parthenogenesis can be best produced is the osmotic pressure. It has been possible to cause the unfertilized eggs of echinoderms, annelids and mollusks to develop into swimming larvæ by increasing transitorily the osmotic pressure of the surrounding solution. Even in vertebrates (the frog and petromyzon), Bataillon has succeeded in calling forth the first processes of development in this way. In other forms specific chemical influences cause the development, *e. g.*, in the eggs of star-fish diluted acids and, best of all, as Delage has shown, carbon dioxide. In the eggs of *Chœtolopterus* potassium salts produce this result and in the case of *Amphitrite,* calcium salts.

From a sexual cell only a definite organism can arise whose properties can be predicted if we know from which organism the sexual cell originates. The foundations of the theory of heredity were laid by Gregory Mendel in his treatise on the 'Hybrids of Plants,' one of the most prominent papers ever published in biology. Mendel showed in his experiments that certain simple characteristics, as, for example, the round or angular shape of the seeds of peas or the color of their endosperm is already determined in the germ by definite determinants. He showed, moreover, that in the case of the hybridization of certain forms one half of the sexual cells of each child contains the determinants of the one parent, the other half contains the determinants of the other parent. In thus showing that the results of hybridization can be predicted numerically not only for one but for a series of generations, according to the laws of the calculus of probability, he gave not a hypothesis, but an exact theory of heredity. Mendel's experiments remained unnoticed until Hugo de Vries discovered the same facts anew, and at the same time became aware of Mendel's treatise.

The theory of heredity of Mendel and de Vries is in full harmony with the idea of evolution. The modern idea of evolution originated, as is well known, with Lamarck, and it is the great merit of Darwin to have revived this idea. It is, however, remarkable that none of the Darwinian authors seemed to consider it necessary that the transformation of species should be the object of direct observation. It is generally understood in the natural sciences either that direct observation should form the foundation of our conclusions or mathematical laws which are derived from direct observations. This rule was evidently considered superfluous by those writing on the hypothesis of evolution. Their scientific conscience was quieted by the assumption that processes like that of evolution could not be directly observed, as they occurred too slowly, and that for this reason indirect observations must suffice. I believe that this lack of direct observation explains the polemical character of this literature, for wherever we can base our conclusions upon direct observations

polemics become superfluous. It was, therefore, a decided progress when de Vries was able to show that the hereditary changes of forms, so-called 'mutations,' can be directly observed, at least in certain groups of organisms, and secondly, that these changes take place in harmony with the idea that for definite hereditary characteristics definite determinants, possibly in the form of chemical compounds, must be present in the sexual cells. It seems to me that the work of Mendel and de Vries and their successors marks the beginning of a real theory of heredity and evolution. If it is at all possible to produce new species artificially I think that the discoveries of Mendel and de Vries must be the starting point.

It is at present entirely unknown how it happens that in living organisms, as a rule, larger quantities of sexual cells begin to form at a definite period in their existence. Miescher attempted to solve this problem in his researches on the salmon. But it seems that Miescher laid too much emphasis upon a more secondary feature of this phenomenon, namely, that the sexual cells in the salmon apparently develop at the expense of the muscular substance of the animal. According to our present knowledge of the chemical dynamics of the animal body it seems rather immaterial whether the proteins and other constituents of the sexual cell come from the body of the animal or from the food taken up. The causes which determine the formation of large masses of sexual cells in an organism at a certain period of its existence are entirely unknown.

A little more progress has been made in regard to another problem which belongs to this group of phenomena, namely how it happens that in many species one individual forms sperm, the other eggs. It has been known for more than a century that it is possible to produce at desire either females exclusively or both sexes in plant lice. In bees and related forms, as a rule at least, only males originate from the unfertilized eggs; from the fertilized eggs only females. It is, moreover, known that in higher vertebrates those twins which originate from one egg have the same sex, while the sex of twins originating from different eggs may be different. All facts which are thus far known in regard to the determination of sex seem to indicate that the sex of the embryo is already determined in the unfertilized egg, or at least immediately after fertilization. I consider it possible that in regard to the determination of sex, just as in the case of artificial parthenogenesis, a general variable will be found by which we can determine whether an egg cell will assume male or female character.

V.

INSTINCT AND CONSCIOUSNESS.

The difference between our artificial machines and the living organisms appears, perhaps, most striking when we compare the many automatic devices by which the preservation of individuals and species is guaranteed. Where separate sexes exist we find automatic arrangements by which the sexual cells of the two sexes are brought together. Wherever the development of the eggs and larvæ occurs outside of the body of the mother or the nest we often find automatic mechanisms whereby the eggs are deposited in such places as contain food on which the young larva can exist and grow. We have to raise the question how far has the analysis of these automatic mechanisms been pushed. Metaphysics has supplied us with the terms 'instinct' and 'will' for these phenomena. We speak of instinct wherever an animal performs, without foresight of the ends, those acts by which the preservation of the individual or the species is secured. The term 'will' is reserved for those cases where these proc-

esses form constituents of consciousness. The words 'instinct' and 'will' do, however, not give us the variables by which we can analyze or control the mechanism of these actions. Scientific analysis has shown that the motions of animals which are directed towards a definite aim depend upon a mechanism which is essentially a function of the symmetrical structure and the symmetrical distribution of irritability. Symmetrical points of the surface of an animal, as a rule, have the same irritability, which means that, when stimulated equally, they produce the same quantity of motion. The points at the oral pole as a rule possess a qualitatively different or greater irritability than those at the aboral pole. If rays of light or current curves, or lines of diffusion or gravitation, start from one point and strike an organism, which is sensitive for the form of energy involved, on one side only, the tension of the symmetrical muscles or contractile elements does not remain the same on both sides of the body, and a tendency for rotation will result. This will continue until the symmetrical points of the animal are struck equally. As soon as this occurs there is no more reason why the animal should deviate to the right or left from the direction of its plane or axis of symmetry. These phenomena of automatic orientation of animals in a field of energy have been designated as tropisms. It has been possible to dissolve a series of mysterious instincts into cases of simple tropisms. The investigation of the various cases of tropism has shown their great variety and there can be no doubt that further researches will increase the variety of tropisms and tropism-like phenomena. I am inclined to believe that we possess in the tropisms and tropism-like mechanisms the independent variable of such functions as the instinctive selection of food and similar regulatory phenomena.

As far as the mechanism of consciousness is concerned no scientific fact has thus far been found that promises an unraveling of this mechanism in the near future. It may be said, however, that at least the nature of the biological problem here involved can be stated. From a scientific point of view we may say that what we call consciousness is the function of a definite machine which we will call the machine of associative memory. Whatever the nature of this machine in living beings may be, it has an essential feature in common with the phonograph, namely, that it is capable of reproducing impressions in the same chronological order in which they come to us. Even simultaneous impressions of a different physical character, such as, for instance, optical and acoustical, easily fuse in memory and form an inseparable complex. The mechanism upon which associative memory depends seems to be located, in higher vertebrates at least, in the cerebral hemispheres, as the experiments of Goltz have shown. The same author has shown, moreover, that one of the two hemispheres suffices for the efficiency of this mechanism and for the full action of consciousness. As far, however, as the physical or chemical character of the mechanism of memory is concerned, we possess only a few starting points. We know that the nerve cells are especially rich in fatty constituents and Overton and Hans Meyer have shown that substances which are easily soluble in fat also act as very powerful anesthetics, for instance, chloroform, ether and alcohol, and so on. It may be possible that the mechanism of associative memory depends in some way upon the constitution or action of the fatty compounds in our nerve cells. Another fact which may prove of importance is the observation made by Speck that if the partial pressure of oxygen in the air falls below one third of its normal value, mental

activity very soon becomes impaired and consciousness is lost. Undoubtedly the unraveling of the mechanism of associated memory is one of the greatest discoveries which biology has still in store.

VI.

ELEMENTARY PHYSIOLOGICAL PROCESSES.

It is, perhaps, possible that an advance in the analysis of the mechanism of memory will be made when we shall know more about the processes that occur in nerve cells in general. The most elementary mechanisms of self preservation in higher animals are the respiratory motions and the action of the heart. The impulse for the respiratory action starts from the nerve cells. As far as the impulses for the activity of the heart are concerned we can say that in one form at least they start from nerve cells, and in all cases from those regions where nerve cells are situated. But as far as the nature of these impulses is concerned we know as little about the cause of the rhythmical phenomena of respiration and heart beat as we know concerning the mechanism of associative memory. It is rather surprising, but nevertheless a fact, that physiology has not progressed beyond the stage of mere suggestions and hypotheses in the analysis of such elementary phenomena as nerve action, muscular contractility and cell division. Among the suggestions concerning the nature of contractility those seem most promising which take into consideration the phenomena of surface tension. The same lack of definite knowledge is found in regard to the changes in the sense organs which give rise to sensations. It is obvious that the most striking gaps in biology are found in that field of biology which has been cultivated by the physiologists. The reason for this is in part, that the analysis of the elementary protoplasmic processes is especially difficult, but I believe that there are other reasons. Medical physiologists have confined themselves to the study of a few organisms, and this has had the effect that for the last fifty years the same work has been repeated with slight modifications over and over again.

VII.

TECHNICAL BIOLOGY.

I think the creation of technical biology must be considered the most significant turn biology has taken during the last century. This turn is connected with a number of names, among which Liebig and Pasteur are the most prominent. Agriculture may be considered as an industry for the transformation of radiating into chemical energy. It was known for a long time that the green plants were able to build up, with the help of the light, the carbohydrates from the carbon dioxide of the air. Liebig showed that for the growth of the plant definite salts are necessary, that these salts are withdrawn from the soil by the plants, and that in order to produce crops these salts must be given back to the soil. One important point had not been cleared up by the work of Liebig, namely, the source of nitrates in the soil which the plants need for the manufacture of their proteins. This gap was filled by Hellriegel, who found that the tubercles of the leguminosæ, or rather the bacteria contained in these tubercles, are capable of transforming the inert nitrogen of the air into a form in which the plant can utilize it for the synthesis of its proteins. Winogradski subsequently discovered that not only the tubercle bacteria of leguminosæ are capable of fixing the nitrogen of the air in the soil in a form in which it can be utilized by the plant, but that the same can be done by certain other bacteria, for instance, *Chlostridium pasteurianum*. These facts have a bearing which goes beyond the interests of agriculture. The question of

obtaining nitrates from the nitrogen of the air is of importance also for chemical industry, and it is not impossible that chemists may one day utilize the experience obtained in nitrifying bacteria.

With the discovery of the culture of nitrifying bacteria we have already entered the field of Pasteur's work. Yeast had been used for the purposes of fermentation before Pasteur, but Pasteur freed this field of biology just as much from the influence of chance as Liebig did in the case of agriculture. The chemist Pasteur taught biologists how to discriminate between the useful and harmful forms of yeast and bacteria, and thus rendered it possible to put the industry of fermentation upon a safe basis.

In recent times the fact has often been mentioned that the coal fields will be exhausted sooner or later. If this is true every source of available energy which is neglected to-day may one day become of importance. Professor Hensen has recognized the importance of the surface of the ocean for the production of crops. The surface of the ocean is inhabited by endless masses of microscopic organisms which contain chlorophyl and which are capable of transforming the radiating energy of the sun into chemical energy.

Not only through the industry of fermentation and agriculture has technical biology asserted its place side by side with physical and chemical technology, but also in the conquest of new regions for civilization. As long as tropical countries are continually threatened by epidemics no steady industrial development is possible. Biology has begun to remove this danger. It is due to Koch if epidemics of cholera can be suppressed to-day and to Yersin if the spreading of plague can now be prevented. Theobald Smith discovered that the organisms of Texas fever are carried by a certain insect, and this discovery has had the effect of reducing and possibly in the near future destroying two dreaded diseases, namely, malaria and yellow fever.

It is natural that the rapid development of technical biology has reacted beneficially upon the development of theoretical biology. Just as physics and chemistry are receiving steadily new impulses from technology, the same is true for biology. The working out of the problems of immunity has created new fields for theoretical biology. Ehrlich has shown that in the case of immunity toxins are rendered harmless by their being bound by certain bodies, the so-called anti-toxins. The investigation of the nature and the origin of toxins in the case of acquired immunity is a new problem which technical biology has given to theoretical biology. The same may be said in regard to the experiments of Pfeifer and Bordet on bacteriolysis and hemolysis. Bordet's work has led to the development of methods which have been utilized for the determination of the blood relationship of animals.

VIII.

The representatives of the mental sciences often reproach the natural sciences that the latter only develop the material but not the mental or moral interests of humanity. It seems to me, however, that this statement is wrong. The struggle against superstition is entirely carried on by the natural sciences, and especially by the applied sciences. The nature of superstition consists in a gross misunderstanding of the causes of natural phenomena. I have not gained the impression that the mental sciences have been able to reduce the amount of superstition. Lourdes and Mecca are in no danger from the side of the representatives of the mental sciences, but only from the side of scientific medicine. Superstition disappears so slowly for the reason that the masses as a rule are not taught any sciences. If the day comes

when the chief laws of physics, chemistry and experimental biology are generally and adequately taught we may hope to see superstition and all its consequences disappear, but not before this.

As far as the influence of the applied sciences on ethics is concerned, I think we may hope that through the natural sciences the ethics of our political and economical life will be altered. In our political as well as our economical life we are still under the influence of the ancients, especially the Romans, who knew only one means of acquiring wealth, namely by dispossessing others of it. The natural sciences have shown that there is another and more effective way of acquiring wealth, namely, by creating it. The way of doing this consists in the invention of means by which the store of energy present in nature can be more fully utilized. The wealth of modern nations, of Germany and France, is not due to their statesmen or to their wars, but to the accomplishments of the scientists. It has been calculated that the inventions of Pasteur alone added a billion francs a year to the wealth of France. In the light of such facts it seems preposterous that statesmen should continue to instigate war simply for the conquest of territories. Through modern science the wealth of a nation can be increased much more quickly than through any territorial conquest. We can not expect any change in the political and economical ethics of nations until it is recognized that the lawmakers and statesmen must have a scientific training. If our lawmakers possessed such a training they would certainly not have allowed one general source of energy after another, such as oil fields, coal fields, water power, etc., to be appropriated by individuals. All these stores of energy belong just as well to the community as the oxygen of the air or the radiating energy of the sun. Our present economical and political ethics is still on the whole that of the classical period or the renaissance, because the knowledge of science among the masses and statesmen is still on that level, but the natural sciences will ultimately bring about as thorough a revolution in ethics as they have brought about in our material life.

IX.

If we compare the development of biology with the simultaneous development of physics and chemistry during the last twenty years, we must be impressed by the fact that during that time the great discoveries in physics and chemistry have followed each other surprisingly fast. The discovery of the law of osmotic pressure, the theory of electrical disassociation, the theory of galvanic batteries, the systematic formulation of physical chemistry, the discovery of electrical waves, the discovery of the X-rays, the discovery of the new elements in the air, the discovery of radioactivity, the transformation of radium into helium, the theory of radiation pressure—what have we in biology that could be compared with such a series of discoveries? But I believe that biology has important discoveries in store and that there is no intrinsic reason why it should be less fertile than physics and chemistry. I think the difference in the fertility of biology and the physical sciences is at least partly due to the present organization of the biological sciences.

General or experimental biology should be represented in our universities by special chairs and laboratories. It should be the task of this science to analyze and control those phenomena which are specifically characteristic of living organisms, namely, development, self preservation, and reproduction. The methods of general biology must be those of chemistry and especially those of physical chemistry. To-day general or experimental biology is represented

in our universities neither by chairs nor by laboratories. We have laboratories for physiology, but to show how little interest physiologists take in general biology I may mention the fact that the editor of a physiological annual review excludes papers on the development and fertilization from his report, as in his opinion, this belongs to anatomy. On the other hand, anatomists and zoologists must give their full energy to their morphological investigations and have, as a rule, neither the time for experimental work nor very often the training necessary for that kind of work. Only the botanists have kept up their interest in general biology, but they of course pay no attention to animal biology. In working out this short review of the development of biology during the last century I have been impressed with the necessity of our making better provisions for that side of biology where, in my opinion, the chances for the great discoveries seem to lie, namely, *general* or *experimental* biology.

JACQUES LOEB.

THE PROBLEMS OF EXPERIMENTAL PSYCHOLOGY.*

THE first difficulty that confronts one, as one attempts to envisage the problems of experimental psychology, is the difficulty of definition. What is a psychological experiment? What is the scope of experimental psychology? Is experiment simply a method of work, applicable to all or to some special parts of the psychological system; or is experimental psychology a distinct branch of psychology, sharply marked off from other and coordinate branches?

The program of this congress would seem to have decided the issue in the latter sense; for we find sections of general psychology, of comparative and genetic psychology, of abnormal psychology and of social psychology, arranged alongside of our own section of experimental psychology. If, then, I wished to take shelter behind the plan of the program, I might, with some show of justification, confine myself to the discussion of those problems in normal, human, adult psychology which still form the staple material of experimental investigation in the laboratories, and might omit all reference to the extensions of the experimental method to outlying fields. Such a course would, nevertheless, be unsatisfactory. The extensions of the method are coming to play a larger and larger part in psychological discussions and in our psychological literature; and it behooves us to take up a stand with regard to them, positive or negative, appreciative or critical. I shall try not to shirk this duty. Let me say, however, at the outset —and I shall have more to say upon the matter presently—that, whatever else experimental psychology may be, there can be no doubt that the subjects to which the program apparently limits us are experimental psychology. The examination, under strictly controlled and properly varied conditions, of the normal, adult, human mind—this is psychological experiment in its pure, primary and typical form. And it is this typical experimental psychology the problems of which we have, in the first place, to consider.

In approaching this question of the problems of experimental psychology, it seemed to me that the surest key to the future lay in the accomplishment of the past. The best way to find out what experimental psychology has to do is, I thought, to make certain of what it has already done. With this idea in mind, I naturally had recourse to our bibliographies—the American bibliography of the *Psychological Review*, and the German of the *Zeitschrift f. Psychologie*. The result was not encouraging. We

* Address delivered at the International Congress of Arts and Science, St. Louis, September, 1904.